PATENT ABSTRACTS OF JAPAN

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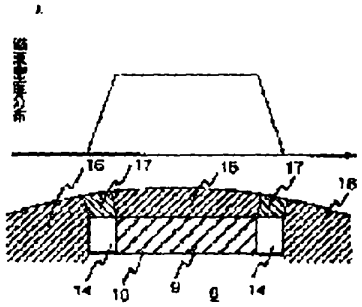
(54) PERMANENT MAGNET DYNAMO-ELECTRIC MACHINE AND MOTOR-DRIVEN VEHICLE USING THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To suppress a torque ripple while a reluctance torque by an auxiliary pole is obtained, by a method wherein magnetic gaps are formed between a permanent magnet and auxiliary pole parts adjacent to the permanent magnet in a circumferential direction.
SOLUTION: Magnetic gaps 14 are formed between a permanent magnet 9 and auxiliary pole parts adjacent to the permanent magnet 9 in a circumferential direction to relieve the change of a magnetic flux distribution. Bridge parts 17 are formed between a pole piece part 15 and auxiliary poles 16 on the surface of a rotor by the gaps 14, and certain distances are provided between the pole piece part 15 and the auxiliary poles 16. Therefore, the change of a magnetic flux distribution which is more gentle than that of a conventional constitution is obtained, so that a cogging torque and a torque ripple can be suppressed. Further, if a dynamo-electric machine rotates in one direction only, the magnetic gap 14 may be formed on the one end in the circumferential direction of a permanent magnet 9. Moreover, if the similar gaps 14 are formed between the auxiliary pole parts and the arc-shaped or trapezoidal permanent magnets 9, the similar effect can be obtained.



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* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] the stator which is characterized by providing the following and which gave the coil to the stator core, and two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- a hole -- annular -- forming -- and this permanent magnet insertion -- the permanent magnet rotation electrical machinery which consisted of rotators which embedded the permanent magnet at the hole, and has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further The aforementioned permanent magnet. An opening magnetic between the aforementioned auxiliary magnetic pole sections which adjoined the aforementioned permanent magnet at the hoop direction.
[Claim 2] permanent magnet rotation electrical machinery according to claim 1 -- setting -- the aforementioned permanent magnet insertion -- the permanent magnet rotation electrical machinery characterized by having established the crevice in the bottom of a hole and having arranged the aforementioned permanent magnet to this crevice
[Claim 3] Permanent magnet rotation electrical machinery characterized by having arranged the non-magnetic material to the aforementioned opening in permanent magnet rotation electrical machinery according to claim 1 or 2.
[Claim 4] Permanent magnet rotation electrical machinery characterized by making hoop-direction width of face of the field by the side of the stator of the aforementioned opening larger than the hoop-direction width of face of the field by the side of the wastepaper constant child of this opening in permanent magnet rotation electrical machinery according to claim 1 to 3.
[Claim 5] It is the permanent magnet rotation electrical machinery characterized by the hoop-direction cross section of the aforementioned opening being a triangle-like in permanent magnet rotation electrical machinery according to claim 4.
[Claim 6] It is the permanent magnet rotation electrical machinery which the aforementioned pole piece section is connected to the aforementioned auxiliary magnetic pole through the bridge section in permanent magnet rotation electrical machinery according to claim 1 to 5, and is characterized by the stator side front face of the aforementioned bridge section and an opening side front face being abbreviation parallel.
[Claim 7] It is the permanent magnet rotation electrical machinery characterized by forming so that the aforementioned bridge section may be extended at right angles to the inclined plane of the aforementioned opening in permanent magnet rotation electrical machinery according to claim 6.
[Claim 8] Permanent magnet rotation electrical machinery characterized by providing the following. The stator which gave the coil to the stator core. two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- a hole -- annular -- forming -- and this permanent magnet insertion -- the permanent magnet rotation electrical machinery which consisted of rotators which embedded the permanent magnet at the hole, and has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further -- setting -- an opening magnetic between the aforementioned pole piece section and the aforementioned auxiliary magnetic pole section
[Claim 9] It is the permanent magnet rotation electrical machinery characterized by the aforementioned opening touching the hoop-direction edge of the field by the side of the stator of the aforementioned permanent magnet in permanent magnet rotation electrical machinery according to claim 8.
[Claim 10] It is the permanent magnet rotation electrical machinery characterized by having extended the aforementioned opening inside the aforementioned permanent magnet in permanent magnet rotation electrical machinery according to claim 9.
[Claim 11] It is the permanent magnet rotation electrical machinery characterized by having extended the aforementioned opening in the shape of a rectangle inside the aforementioned permanent magnet in permanent magnet rotation electrical machinery according to claim 9.
[Claim 12] A hole is formed annularly. the stator which gave the coil to the stator core, and two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- In the permanent magnet rotation electrical machinery which consisted of rotators which embedded the permanent magnet at the hole, and has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further and this permanent magnet insertion -- Permanent magnet rotation electrical machinery characterized by having prepared the magnetic opening between the aforementioned pole piece section and the aforementioned auxiliary magnetic pole section, and making the aforementioned pole piece section fix to the aforementioned auxiliary magnetic pole section by nonmagnetic pole piece supporter material.
[Claim 13] It is the permanent magnet rotation electrical machinery characterized by inserting the aforementioned pole piece supporter material from the shape of a typeface of KO, and both the shafts of the aforementioned rotor core in permanent magnet rotation electrical machinery according to claim 12.
[Claim 14] A hole is formed annularly. the stator which gave the coil to the stator core, and two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- In the permanent magnet rotation electrical machinery which consisted of rotators which embedded the permanent magnet at the hole, and has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further and this permanent magnet insertion -- Prepare a magnetic opening between the aforementioned pole piece section and the aforementioned auxiliary magnetic pole section, and the permanent magnet supporter material which combined the magnetic material and the non-magnetic material between the aforementioned pole piece section and the aforementioned permanent magnet is arranged. And permanent magnet rotation electrical machinery characterized by having arranged the aforementioned magnetic material of the aforementioned permanent magnet supporter material between the aforementioned pole piece section and the aforementioned

permanent magnet, and making the aforementioned non-magnetic material engage with the aforementioned auxiliary magnetic pole section.
[Claim 15] Permanent magnet rotation electrical machinery characterized by having arranged the non-magnetic material to the aforementioned opening in permanent magnet rotation electrical machinery according to claim 8 to 14.
[Claim 16] It is the permanent magnet rotation electrical machinery characterized by the hoop-direction width of face of the aforementioned permanent magnet being smaller than the hoop-direction width of face of the aforementioned auxiliary magnetic pole section in permanent magnet rotation electrical machinery according to claim 1 to 15.
[Claim 17] The electric vehicles driven with permanent magnet rotation electrical machinery according to claim 1 to 16.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the electric vehicles which used rotation electrical machinery and rotation electrical machinery, especially relates to the electric vehicles using the permanent magnet rotation electrical machinery using the permanent magnet as a magnetic-flux generating means, and permanent magnet rotation electrical machinery.
[0002]
[Description of the Prior Art] The permanent magnet rotation electrical machinery which used the permanent magnet for the magnetic field generating means of a rotator is conventionally used as a kind of rotation electrical machinery.
[0003] As conventional permanent magnet rotation electrical machinery, there are some which juxtaposed two or more permanent magnets and were fixed to the front face of a rotator so that surface magnet structure, i.e., an adjoining permanent magnet, may serve as reversed polarity at a hoop direction.
[0004] However, the permanent magnet rotator of the permanent magnet embedded structure which the thing of surface magnet structure inserted the permanent magnet in the hole extended to the shaft orientations in a rotator since possibility that a permanent magnet will exfoliate with a centrifugal force at the time of high-speed rotation is high, and was fixed is indicated by JP,5-76146,A.
[0005] Moreover, what formed the opening in the periphery of a rotator from the end face of each permanent magnet which installed the composition in the case of giving a skew to the rotator of a permanent magnet embedded structure in the interior of a rotator for the purpose of making it simple is indicated by JP,5-236687,A.
[0006]
[Problem(s) to be Solved by the Invention] However, with the above-mentioned conventional technology, there is a problem that it is incompatible with acquiring the reluctance torque by the auxiliary magnetic pole in reduction of cogging torque or torque throb (both are hereafter called "torque throb" collectively).
[0007] Reluctance torque can be acquired by using the rotator member between the adjoining permanent magnets as an auxiliary magnetic pole, and controlling the synthetic vector of the armature magnetomotive force of a stator by the rotator of a permanent magnet embedded structure to turn to a hand-of-cut side from the center position of this auxiliary magnetic pole. This reluctance torque is added to the main torque by the permanent magnet, increases the total torque of rotation electrical machinery, and raises efficiency.
[0008] On the other hand, in order to use the permanent magnet which has always generated magnetic flux irrespective of the existence of energization in permanent magnet rotation electrical machinery, a rotator always receives the force according to the physical relationship of a permanent magnet and the stator salient pole section, and the force changes in throb at the time of rotation. It serves as torque throb and appears. This bars smooth rotation of a rotator and produces the problem that operation stabilized as rotation electrical machinery cannot be obtained.
[0009] Since it has the auxiliary magnetic pole, although it is possible to acquire reluctance torque, since the distance of a permanent magnet and an auxiliary magnetic pole is minute to a hoop direction, the abrupt change of a flux density distribution there appears, and torque throb produces the permanent magnet rotator indicated by JP,5-76146,A.
[0010] Although it becomes loose [the permanent magnet rotation electrical machinery currently indicated by JP,5-236687,A] flux density distribution changing between the permanent magnets which adjoined each other that the opening is prepared between permanent magnets or by filling up with the adhesive filler which becomes an opening from non-magnetic material and it is hard to generate cogging torque or torque throb, since this opening or filler does not achieve the duty of an auxiliary magnetic pole, reluctance torque cannot be acquired.
[0011] this invention aims at offering the permanent magnet rotation electrical machinery which can suppress torque throb, and the electric vehicles using it, acquiring the reluctance torque by the auxiliary magnetic pole in view of the above-mentioned situation.
[0012]
[Means for Solving the Problem] A hole is formed annularly. the stator by which invention according to claim 1 gave the coil to the stator core, and two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- In the permanent magnet rotation electrical machinery which consisted of rotators which embedded the permanent magnet at the hole, and has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further and this permanent magnet insertion -- It is characterized by preparing a magnetic opening between the aforementioned permanent magnet and the aforementioned auxiliary magnetic pole section which adjoined the aforementioned permanent magnet at the hoop direction.
[0013] This magnetic opening makes loose flux density distribution change between the permanent magnet in the hoop direction of a rotator, and an auxiliary magnetic pole, and decreases torque throb. Therefore, this opening may be mere space, and may be arranged or filled up with a non-magnetic material.
[0014] moreover, this opening -- the ends of a permanent magnet -- you may be -- moreover, the hand of cut of rotation electrical machinery and its use -- the hoop direction of a permanent magnet -- either -- you may be only in an end
[0015] However, by preparing the above-mentioned opening in the hoop-direction edge of a permanent magnet, positioning of a magnet may become unstable at the time of high-speed rotation etc. then -- being according to claim 2 -- like -- the

aforementioned permanent magnet insertion -- it is possible to establish a crevice in the bottom of a hole, and to arrange the aforementioned permanent magnet to this crevice, or to position a permanent magnet by the thing [arranging a non-magnetic material] according to claim 3 to the aforementioned opening like

[0016] Moreover, if flux density distribution change to a stator is made loose, since it is sufficient for the aforementioned opening, it can also assist an operation of an auxiliary magnetic pole by changing the configuration. That is, a thing [constituting so that hoop-direction width of face of the field by the side of the stator of the aforementioned opening may be made larger than the hoop-direction width of face of the field by the side of the wastepaper constant child of this opening or the magnetic flux of an auxiliary magnetic pole may tend to go a permanent magnet around like by / according to claim 5 / constituting the hoop-direction cross section of the aforementioned opening like so that it may become triangle-like] according to claim 4 is also possible, and more reluctance torque can be acquired.

[0017] Furthermore, it is possible to suppress the magnetic flux according to claim 6 which the aforementioned pole piece is connected to the aforementioned auxiliary magnetic pole through [like] the bridge section, and forms a stator side front-face side [of the aforementioned bridge section] and opening side front face in abbreviation parallel, or is revealed to the auxiliary magnetic pole from the member by the side of the stator of a permanent magnet to an opening by [according to claim 7] forming so that it may be extended by the aforementioned bridge section at right angles to the inclined plane of the aforementioned opening like.

[0018] Especially according to invention according to claim 7, the centrifugal force concerning a permanent magnet can be supported according to the hauling force of the bridge section, and the permanent magnet rotation electrical machinery more which can be rotated high-speed can be offered.

[0019] A hole is formed annularly, the stator by which invention according to claim 8 gave the coil to the stator core, and two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- and this permanent magnet insertion -- it consists of rotators which embedded the permanent magnet at the hole, and is characterized by preparing a magnetic opening between the aforementioned pole piece section and the aforementioned auxiliary magnetic pole section in the permanent magnet rotation electrical machinery which has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further

[0020] Like [this magnetic opening] invention according to claim 1, flux density distribution change between the permanent magnet in the hoop direction of a rotator and an auxiliary magnetic pole is made loose, and torque throb is decreased.

[0021] Moreover, a thing [suppressing the magnetic flux according to claim 10 which reveals the aforementioned opening to the auxiliary magnetic pole section from the field by the side of the stator of a permanent magnet by / according to claim 11 / forming the aforementioned opening like so that it may be extended in the shape of a rectangle inside the aforementioned permanent magnet so that it may be extended inside the aforementioned permanent magnet like] according to claim 9 is possible so that the hoop-direction edge of the field by the side of the stator of the aforementioned permanent magnet may be touched in the aforementioned opening like.

[0022] However, in inner rotor type rotation electrical machinery, preparing an opening in the pole piece section in the stator side of a permanent magnet may hurt the bearing power to the centrifugal force to a permanent magnet at the time of high-speed rotation.

[0023] Then, the stator according to claim 12 which gave the coil to the stator core like, A hole is formed annularly, two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- In the permanent magnet rotation electrical machinery which consisted of rotators which embedded the permanent magnet at the hole, and has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further and this permanent magnet insertion -- Like a publication to preparing a magnetic opening between the aforementioned pole piece section and the aforementioned auxiliary magnetic pole section, and making the aforementioned pole piece section fix to the aforementioned auxiliary magnetic pole section by nonmagnetic pole piece supporter material, or a claim 13 By being inserted from the shape of a typeface of KO, and both the shafts of the aforementioned rotor core, the aforementioned pole piece supporter material can support the centrifugal force of the permanent magnet concerning the pole piece section in the auxiliary magnetic pole section.

[0024] Moreover, the stator according to claim 14 which gave the coil to the stator core like, A hole is formed annularly, two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- In the permanent magnet rotation electrical machinery which consisted of rotators which embedded the permanent magnet at the hole, and has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further and this permanent magnet insertion -- Prepare a magnetic opening between the aforementioned pole piece section and the aforementioned auxiliary magnetic pole section, and the permanent magnet supporter material which combined the magnetic material and the non-magnetic material between the aforementioned pole piece section and the aforementioned permanent magnet is arranged. And the bearing power to the centrifugal force which a permanent magnet receives similarly can be made to increase also by arranging the aforementioned magnetic material of the aforementioned permanent magnet supporter material between the aforementioned pole piece section and the aforementioned permanent magnet, and making the aforementioned non-magnetic material engage with the aforementioned auxiliary magnetic pole section.

[0025] Furthermore, the bearing power to the centrifugal force which a permanent magnet receives can be made to increase like also by [according to claim 15] arranging a non-magnetic material to the aforementioned opening.

[0026] Moreover, the centrifugal force concerning a permanent magnet is [like] effectively mitigable also by [according to claim 16] making hoop-direction width of face of the aforementioned permanent magnet smaller than the hoop-direction width of face of the aforementioned auxiliary magnetic pole section.

[0027] Invention according to claim 17 is electric vehicles driven with a claim 1 or permanent magnet rotation electrical machinery according to claim 16, and can offer electric vehicles with the stable driving gear with little cogging torque.

[0028] In addition, even if the above-mentioned rotation electrical machinery is which thing of a generator and a motor, an inner rotor and an outer rotor, a rotated type and a linear type, a concentrated winding, and distribution volume stator structure, it can apply this invention.

[0029] Moreover, invention of all above is not dependent on the configuration of a permanent magnet, and anythings can apply a rectangular parallelepiped, an arc form, a trapezoid, etc., and it does the same effect so.

[0030]

[Embodiments of the Invention] Hereafter, the operation gestalt of this invention is explained in detail using drawing.

[0031] Drawing 1 shows the hoop-direction cross section of the permanent magnet rotation electrical machinery of the inner

rotor type concentrated-winding stator structure which is 1 operation gestalt of this invention.
[0032] Rotation electrical machinery consists of a stator 1 and a rotator 2, and these are mutually arranged with a rotation opening, as shown in drawing.
[0033] A stator 1 consists of a stator core 3 and a stator winding 4, and a stator core 3 consists of the core section 5 and the stator salient pole section 6 further. The magnetic circuit for letting magnetic flux pass in the stator salient pole section 6 is formed in the core section 5, and a stator winding 4 is intensively wound around the stator salient pole section 6.
[0034] A rotator 2 consists of a shaft 7, a rotor core 8, and a permanent magnet 9. the permanent magnet insertion which inserts a permanent magnet 9 in a rotor core 8 -- the hole which lets a hole 10 and a shaft 7 pass is pierced by shaft orientations, and a permanent magnet 9 and a shaft 7 are inserted and fixed, respectively
[0035] thus, the permanent magnet insertion which this operation gestalt is the so-called thing of a permanent magnet embedded structure, and adjoins mutually by arranging a permanent magnet 9 annularly to a rotator 2 -- the member between holes 10 can be operated as the auxiliary magnetic pole section 16
[0036] That is, if the synthetic vector of the armature magnetomotive force by the stator winding 4 is controlled by the control unit which is not illustrated to turn to a hand-of-cut side from the center position of an auxiliary magnetic pole, the magnetic flux generated from the stator winding 4 will go a permanent magnet 9 around through the auxiliary magnetic pole section 16, and reluctance torque will occur with it. This is effective in especially low-speed operational status, and the above-mentioned reluctance torque can acquire torque high as a motor by joining the usual torque by the permanent magnet 9.
[0037] Drawing 3 shows the cross-section structure of the shaft orientations of the permanent magnet rotation electrical machinery concerning this operation form.
[0038] The shaft 7 which the stator 1 was fixed to the inner skin of housing 11 as shown in drawing, and was inserted and fixed to the rotator 2 is held with bearing 13 and the end bracket 12 at a stator 1 so that a rotator 2 may have a rotation opening in a stator 1 and may touch it free [rotation].
[0039] With this operation form, what has the permeability higher than a permanent magnet 9 as a material of a rotor core 8, for example, a high permeability magnetic material like a silicon steel, is used. The eddy current loss generated inside a magnet can be decreased by this, and the above-mentioned auxiliary magnetic pole section 16 can be operated more effectively.
[0040] In addition, this invention can be applied also in any of a generator and motor, inner rotor and outer-rotor, rotated type and linear type, and concentration volume and distribution volume stator structure, and the same effect is acquired.
[0041] This operation form forms the magnetic opening 14 between a permanent magnet 9 and the auxiliary magnetic pole section 16 which adjoined this permanent magnet 9 at the hoop direction.
[0042] Drawing which expanded the circumference of the arbitrary permanent magnets 9 in drawing 1 to drawing 2 is shown. as shown in drawing, an opening 14 is formed in the hoop-direction edge of a permanent magnet 9 -- as -- permanent magnet insertion -- a hole 10 is formed, and a permanent magnet 9 is inserted there and it fixes to it This opening was extended to shaft orientations and is in contact with a permanent magnet 9 and the auxiliary magnetic pole section 16.
[0043] An operation of this opening 14 is explained using drawing 4 and drawing 5 .
[0044] Drawing 4 and drawing 5 are the hoop-direction cross section of the permanent magnet 9 circumference, and drawing showing the relation of the flux density distribution generated by the permanent magnet 9 from the circumferential front face of a rotator 2. As for drawing 4 , drawing 5 shows the conventional rotator for the rotator using the above-mentioned operation form.
[0045] It functions as a member which transmits the magnetic flux in which, as for the pole piece section 15 of a rotor core 8, the permanent magnet 9 generated both sides to a stator 1, moreover, the adjacent permanent magnet insertion -- the auxiliary magnetic pole section 16 in the member between holes 10, i.e., drawing, functions as an auxiliary magnetic pole which generates reluctance torque
[0046] The graph in the upper part of drawing 4 and drawing 5 expresses the flux density distribution generated by the permanent magnet 9 from the stator side front face of a rotator 2. As for the magnetic flux which a permanent magnet 9 generates, both drawings show the flux density distribution of simultaneously regularity in the pole piece section 15. On the other hand, in the auxiliary magnetic pole section 16, the magnetic flux by the permanent magnet 9 is hard to be transmitted, and the magnetic flux generated from the stator side front face of a rotator 2 is set to about 0.
[0047] however, the permanent magnet insertion prepared in the rotor core 8 like drawing 5 in the conventional rotator -- a hole -- since the permanent magnet 9 is arranged so that the 10 whole may be buried, in near the boundary of the pole piece section 15 and the auxiliary magnetic pole section 16, a rapid change of a flux density distribution as shown in drawing appears
[0048] In permanent magnet rotation electrical machinery, since the permanent magnet has always generated magnetic flux irrespective of the existence of the energization to rotation electrical machinery, a rotator always receives the force according to the physical relationship of the stator salient pole section 6 and the pole piece section 15. If a rotator rotates, when a mutual position changes, the force which a rotator receives changes in pulsation, and this will serve as cogging torque and torque pulsation, and will appear. Torque pulsation is so remarkable that change of the flux density distribution in a rotator hoop direction is rapid.
[0049] Then, an opening 14 is formed like this operation form, and change of a flux density distribution is made loose. Of an opening 14, the bridge section 17 is formed between the auxiliary magnetic pole section 16 on the front face of a rotator, and the pole piece section 15, and distance is established between the pole piece section 15 and the auxiliary magnetic pole 16 by it. Therefore, compared with the former, change of a loose flux density distribution appears like the graph of drawing 4 , and cogging torque and torque pulsation can be suppressed.
[0050] Moreover, with the rotation electrical machinery with which the hand of cut has become settled only in Mukai on the other hand, you may form the magnetic opening 14 only in the hoop-direction end of a permanent magnet 9.
[0051] In addition, although the permanent magnet 9 of a rectangular parallelepiped as shown in drawing is used in this operation form, the same effect is acquired even if it forms the same opening 14 as other things of a configuration, for example, an arc form and a trapezoid thing.
[0052] Other operation forms of this invention are shown in drawing 6 or drawing 8 .
[0053] Drawing 6 and the operation form of drawing 7 change the configuration of the opening 14 of the operation form in drawing 2 .
[0054] the operation form of drawing 6 -- permanent magnet insertion -- a crevice is established in the bottom of a hole 10 and a permanent magnet 9 is arranged to this crevice Consequently, the rotator radial thickness of an opening 14 is formed smaller than the rotator radial thickness of a permanent magnet 9, and as shown in drawing, the field by the side of the wastepaper constant child of an opening 14 is formed in stator approach rather than the field by the side of the wastepaper constant child of

a permanent magnet 9.
[0055] these -- a permanent magnet 9 -- permanent magnet insertion -- it can position to the position of a hole 10
[0056] Moreover, for positioning of a permanent magnet 9, even if it arranges or fills up an opening 14 with a non-magnetic material, the same effect can be acquired. For example, by arranging the solid-state which changes from a non-magnetic material to an opening 14, and making one fix with a varnish and adhesives, it is stabilized more and a permanent magnet 9 can be arranged.
[0057] Moreover, the operation form of drawing 7 makes hoop-direction width of face of the field by the side of the stator of an opening 14 larger than the hoop-direction width of face of the field by the side of a wastepaper constant child. Especially in drawing 7 , it forms so that the hoop-direction cross section of an opening 14 may become abbreviation triangle-like. By this, the magnetic flux which passes along the auxiliary magnetic pole section 16 can go a permanent magnet 9 around smoothly, and more reluctance torque can be acquired.
[0058] Furthermore, in drawing 6 and the operation form of drawing 7 , the field by the side of the stator of an opening 14 is formed so that it may become abbreviation parallel on the stator side front face of a rotator 2.
[0059] By this, the magnetic saturation of the bridge section 17 becomes tight, and the magnetic flux generated from a permanent magnet 9 can suppress the magnetic flux revealed to the auxiliary magnetic pole section 16 through the pole piece section 15 and the bridge section 17.
[0060] The operation form of drawing 8 changes the configuration of a rotator 2 conversely in order to obtain the same composition. That is, it is constituted so that the bridge section 17 may be extended to an abbreviation perpendicular at inclined plane 14a of an opening 14. The centrifugal force applied to the pole piece section 15 and a permanent magnet 9 by this by the inclination of the bridge section 17 to radial [of a rotator 2] becoming large is supportable with the hauling force of the bridge section 17. Generally the endurance of material has the endurance higher than the above-mentioned operation form in which it is higher to pull [rather than] to shearing force and to receive the force, and the bridge section 17 makes a right angle mostly to radial [of a rotator 2] over a centrifugal force. Therefore, the bridge section 17 is formed more thinly, it is also possible to raise the amount of effective magnetic flux generated from a permanent magnet 9, and a rotator can be rotated more at high speed.
[0061] Other operation forms of this invention are shown in drawing 9 or drawing 11 .
[0062] These form the magnetic opening 14 between the pole piece section 15 and the auxiliary magnetic pole section 16, and an opening 14 is formed in the ends of the pole piece section 15 as shown in drawing. This opening 14 is extended to shaft orientations along the stator side hoop-direction edge of a permanent magnet 9. Of this opening 14, the bridge section 17 as shown in drawing is formed, the flux density distribution in the portion changes gently, and it becomes possible to suppress cogging torque.
[0063] Furthermore, by drawing 9 or drawing 11 , it forms so that an opening 14 may touch the hoop-direction edge of the field by the side of the stator of a permanent magnet 9 and it may enter inside from the hoop-direction end face of a permanent magnet 9. Moreover, at drawing 10 , it forms so that an opening 14 may be extended toward the inside of a permanent magnet 9, and by drawing 11 , it forms so that an opening 14 may be extended in the shape of a rectangle inside a permanent magnet 9.
[0064] When the magnetic flux revealed to the auxiliary magnetic pole section 16 decreases by this and the flux density in the pole piece section 15 increases, efficiency can be raised as rotation electrical machinery. Other operation forms of this invention are shown in drawing 12 or drawing 14 .
[0065] When rotating the rotator of a permanent magnet embedded structure at high speed, the centrifugal force which a permanent magnet receives increases and the burden of the member 15 which supports a permanent magnet, i.e., the pole piece section, and the bridge section 17 increases. When it corresponds to the burden and this member is prepared thickly, the distance of a rotator front face and a permanent magnet is large and a bird clapper and magnetic flux are revealed to the auxiliary magnetic pole section 16, the problem that the magnetic flux transmitted from a permanent magnet to a stator decreases, and torque decreases arises.
[0066] Then, the magnetic opening 14 extended to shaft orientations in a cross section like drawing 12 is formed in the hoop-direction ends of the field by the side of the stator of a permanent magnet 9, and the pole piece supporter material 18 is inserted in shaft orientations, and it fixes to the pole piece section 15 and the auxiliary magnetic pole section 16 so that an opening 14 may be pinched. Drawing 13 is the example of the pole piece supporter material 18, and is taken as the nonmagnetic resin which carried out the typeface of KO here. The axial sectional view of permanent magnet rotation electrical machinery with the rotator 2 by which the pole piece supporter material 18 was inserted in drawing 14 from the both sides of a rotor core 8 is shown.
[0067] An opening 14 suppresses the magnetic flux revealed from the pole piece section 15 to the auxiliary magnetic pole section 16 here. Moreover, the pole piece supporter material 18 works as a medium for having the auxiliary magnetic pole section 16 and supporting the centrifugal force of the permanent magnet 9 concerning the pole piece section 15, and pole piece section 15 self. This can raise the bearing power of a permanent magnet to a centrifugal force.
[0068] Furthermore, the magnetic leakage flux by the bridge section 17 can also be decreased, maintaining the bearing power of the pole piece section 15 by the pole piece supporter material 18 by cutting the bridge section 17 in drawing 12 after the assembly of a rotator 2.
[0069] Other operation forms of this invention are shown in drawing 15 .
[0070] Here, as shown in drawing, the magnetic opening 14 is formed between the pole piece section 15 and the auxiliary magnetic pole section 16, and the permanent magnet supporter material 19 which combined the magnetic material and the non-magnetic material between a permanent magnet 9 and the pole piece section 15 is formed.
[0071] The permanent magnet supporter material 19 is the combination of magnetic material 19a and non-magnetic material 19b, as shown in drawing, and it joins both by welding etc. Magnetic material 19a is constituted from material of the magnetic substance, in order to transmit the generating magnetic flux of a permanent magnet 9 to the pole piece section 15, and non-magnetic material 19b consists of material of non-magnetic material, in order to suppress the magnetic leakage flux from the permanent magnet 9 to the auxiliary magnetic pole section 16.
[0072] By the above composition, the centrifugal force concerning a permanent magnet 9 can be supported in the auxiliary magnetic pole section 16 through the permanent magnet supporter material 19, and the centrifugal force of the pole piece section 15 serves as this chisel at the bridge section 17. Therefore, the radial length of the bridge section 17 can be shortened, therefore magnetic-flux disclosure from a permanent magnet 9 can be lessened.
[0073] Or it is also effective to set in drawing 9 or the operation form of drawing 11 , and to arrange or fill up an opening 14 with a non-magnetic material.
[0074] The thickness of the pole piece section 15 is set as thickness required in order to acquire sufficient magnetic flux, an

opening 14 is pierced in drawing 9 or a configuration like drawing 11 to the stator side of a permanent magnet 9, and it considers as the composition filled up with a nonmagnetic material, for example, adhesives, and a varnish there. The centrifugal force which a permanent magnet 9 and the pole piece section 15 receive can be supported by the opening 14, without making the pole piece section 15 thick to radial by this.
[0075] Moreover, it is also possible as a material of a permanent magnet 9 to use a resin magnet. in this case, instead of [of a nonmagnetic material with which an opening 14 is filled up] -- a resin magnet -- permanent magnet insertion -- it can insert in in the configuration where the opening 14 was doubled with the hole 10 That is, it becomes possible to make the plastics magnet itself serve as the above roles of an opening 14. Furthermore, it is also more effective than the hoop-direction width of face of a permanent magnet 9 like drawing 16 to prepare greatly the hoop-direction width of face of the auxiliary magnetic pole section 16.

[0076] The weight of the permanent magnet 9 which makes the centrifugal force concerning the bridge section 17 by this can be mitigated, thickness of the bridge section 17 can be made smaller, and the magnetic flux revealed to the auxiliary magnetic pole section 16 from the pole piece section 15 can be decreased.
[0077] In addition, the hoop-direction width of face of a permanent magnet 9 is small, and although the magnetic flux generated from a permanent magnet 9 by the bird clapper decreases, the reluctance torque by the auxiliary magnetic pole section 16 increases relatively. This is effective when a neodium magnet expensive as a permanent magnet 9 is used, and improvement in cost performance can be aimed at by compensating the part of the cost cut by reducing the amount of a permanent magnet 9 with the reluctance torque of the auxiliary magnetic pole section 16.
[0078] In addition, if the permanent magnet rotation electrical machinery described above is applied to electric vehicles, especially an electric vehicle, there can be little cogging torque, can carry the stable permanent magnet rotation electrical machinery driving gear which can depart smoothly, and can offer an electric vehicle with long 1 charge mileage.
[0079]
[Effect of the Invention] According to invention according to claim 1, permanent magnet rotation electrical machinery with little torque throb can be constituted.
[0080] According to a claim 2 and invention according to claim 3, in addition to the same effect as a claim 1, positioning of a permanent magnet is attained.
[0081] According to a claim 4 and invention according to claim 5, it is possible to constitute so that the magnetic flux which passes along an auxiliary magnetic pole further may go a permanent magnet around smoothly.
[0082] According to a claim 6 and invention according to claim 7, it becomes possible further to suppress the magnetic flux revealed from the member by the side of the stator of an opening to an auxiliary magnetic pole from a permanent magnet.
[0083] Moreover, permanent magnet rotation electrical machinery with little torque throb is realizable with invention according to claim 8.
[0084] According to a claim 9 or invention according to claim 11, in addition to the same effect as a claim 8, the magnetic flux revealed to the auxiliary magnetic pole section from the field by the side of the stator of a permanent magnet can be suppressed.

[0085] Furthermore, according to a claim 12 or invention according to claim 16, in addition to the effect of reduction of torque throb, the bearing power to the centrifugal force concerning a permanent magnet is securable.
[0086] According to invention according to claim 17, electric vehicles with the stable driving gear with little cogging torque can be offered.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The hoop-direction cross section of the permanent magnet rotation electrical machinery which makes 1 operation gestalt of this invention.
[Drawing 2] The enlarged view of the permanent magnet circumference with the arbitrary rotator of drawing 1 .
[Drawing 3] The axial sectional view of the operation gestalt of drawing 1 .
[Drawing 4] the rotator of drawing 2 -- the functional description view of a member, and a flux density distribution
[Drawing 5] the rotator of the conventional permanent magnet rotation electrical machinery -- the functional description view of a member, and a flux density distribution
[Drawing 6] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 7] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 8] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 9] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 10] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 11] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 12] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 13] The perspective diagram of the pole piece supporter material of drawing 12 .
[Drawing 14] The axial sectional view of the permanent magnet rotation electrical machinery of drawing 12 .
[Drawing 15] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 16] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Description of Notations]
1 -- stator and 2 -- -- a rotator, 3 -- stator core, 4 -- stator winding, and 5 -- -- the core section, 6 -- stator salient pole section, 7 -- shaft, and 8 -- -- a rotor core, 9 -- permanent magnet, and 10 -- permanent magnet insertion -- a hole, 11 -- housing, 12 -- and a bracket, 13 -- bearing, and 14 -- -- an opening, 15 -- pole piece section, the 16 -- auxiliary magnetic pole section, and 17 -- -- the bridge section, 18 -- pole piece

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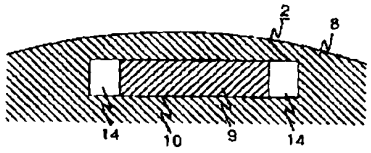
[Translation done.]

* NOTICES *

DRAWINGS

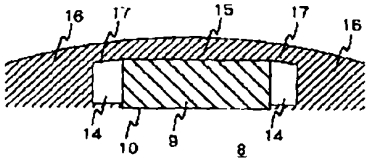
[Drawing 2]

図 2



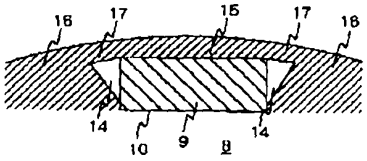
[Drawing 6]

図 6



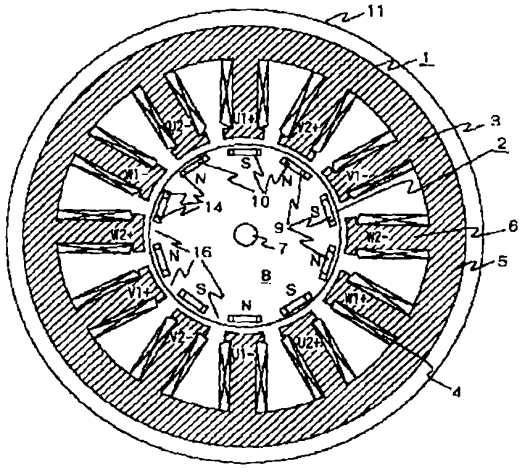
[Drawing 7]

図 7



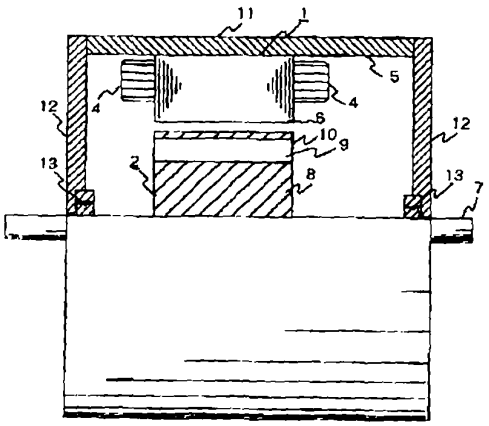
[Drawing 1]

図 1



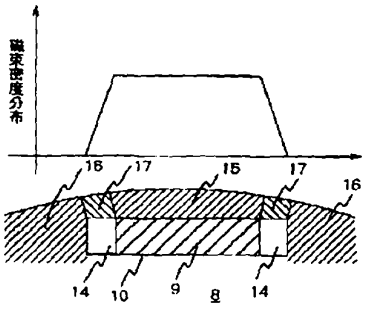
[Drawing 3]

図 3



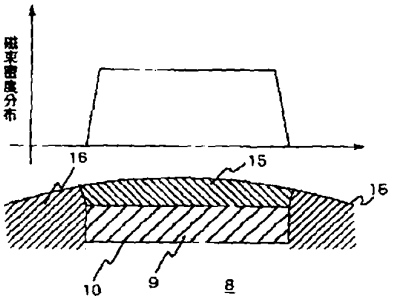
[Drawing 4]

図 4



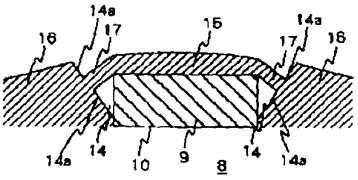
[Drawing 5]

図 5



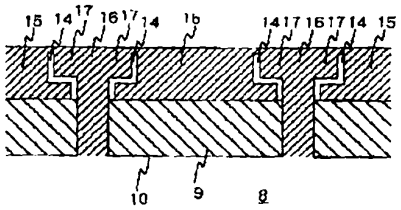
[Drawing 8]

図 8



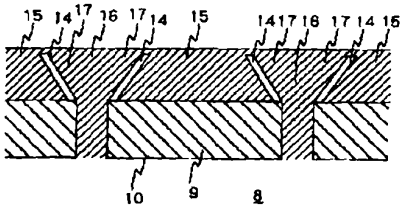
[Drawing 9]

図 9



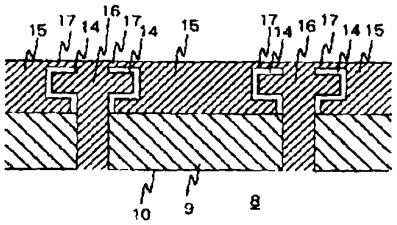
[Drawing 10]

図 10



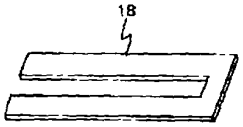
[Drawing 11]

図 11



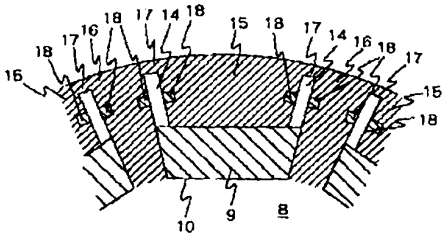
[Drawing 13]

図 13



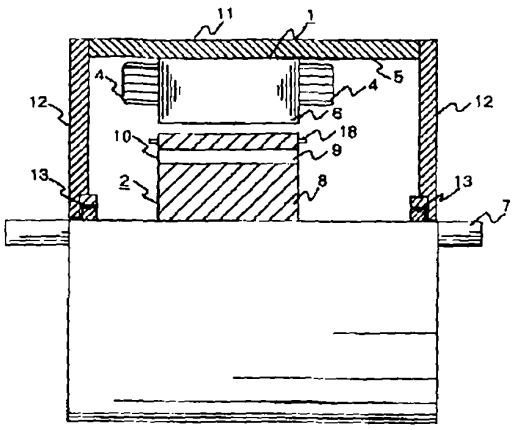
[Drawing 12]

図 12



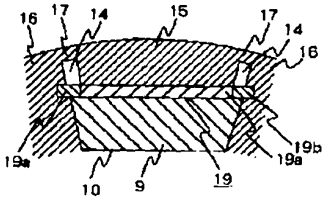
[Drawing 14]

図 14



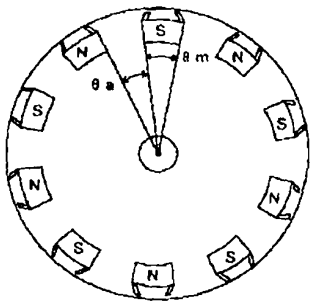
[Drawing 15]

図 15



[Drawing 16]

図 16



[Translation done.]

* NOTICES *

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[FI]

H02K 1/27 501 A .

[Procedure revision]
[Filing Date] October 31, Heisei 12 (2000. 10.31)
[Procedure amendment 1]
[Document to be Amended] Specification.
[Item(s) to be Amended] Claim.
[Method of Amendment] Change.
[Proposed Amendment]
[Claim(s)]
[Claim 1] Permanent magnet rotation electrical machinery characterized by providing the following. Stator. The rotator arranged through an opening at the inner circumference side of this stator. two or more permanent magnet insertion annularly arranged while being formed in this rotator -- a hole these permanent magnet insertion of two or more -- the auxiliary magnetic pole section prepared between the permanent magnet embedded at the hole, and the aforementioned permanent magnet which adjoins a hoop direction while being formed in the aforementioned rotator -- having -- an opening magnetic between the aforementioned permanent magnet and the aforementioned auxiliary magnetic pole section
[Claim 2] Permanent magnet rotation electrical machinery characterized by providing the following. Stator. The rotator arranged through an opening at the inner circumference side of this stator. two or more permanent magnet insertion annularly arranged while being formed in this rotator -- a hole these permanent magnet insertion of two or more -- the auxiliary magnetic pole section prepared between the permanent magnet embedded at the hole, and the aforementioned permanent magnet which adjoins a hoop direction while being formed in the aforementioned rotator, and the pole piece section arranged at the aforementioned stator side of the aforementioned permanent magnet -- having -- an opening magnetic between the aforementioned auxiliary magnetic pole section and the aforementioned pole piece section
[Claim 3] Permanent magnet rotation electrical machinery characterized by preparing nonmagnetic material in the aforementioned opening in permanent magnet rotation electrical machinery according to claim 1 or 2.
[Claim 4] It is the permanent magnet rotation electrical machinery characterized by being the thing which the aforementioned opening makes [thing] change of a flux density distribution loose in permanent magnet rotation electrical machinery according to claim 1 or 2, and makes cogging torque suppress.
[Claim 5] They are the electric vehicles characterized by the aforementioned driving gear having permanent magnet rotation electrical machinery according to claim 1 to 4 in the electric vehicles equipped with the driving gear.

[Translation done.]

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(51)Int.Cl.[6]	識別記号	Ｆ Ｉ	
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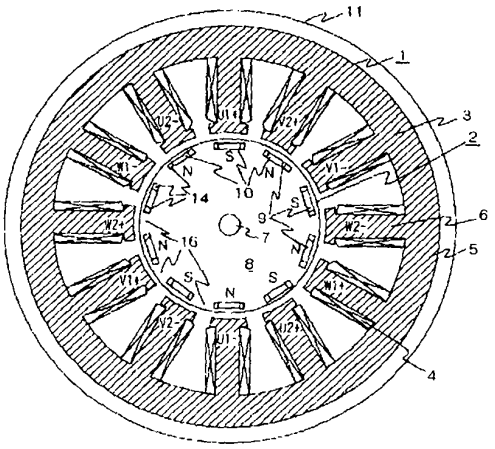
最終頁に続く

(54)【発明の名称】　永久磁石回転電機および永久磁石回転電機を用いた電動車両

(57)【要約】
【課題】補助磁極によるリラクタンストルクを得ながら、コギングトルクやトルク脈動を抑えた永久磁石回転電機、およびそれを用いた電動車両を提供する。
【解決手段】回転子の永久磁石と、該永久磁石に周方向に隣り合った補助磁極との間に磁気的な空隙を設けることにより、回転子の表面の磁束密度分布変化を緩やかにし、コギングトルクやトルク脈動を抑える。

図　1



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【特許請求の範囲】

【請求項１】固定子鉄心に巻線を施した固定子と、間に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に回転空隙をもって配置した永久磁石回転電機において、前記永久磁石と、前記永久磁石に周方向に隣り合った前記補助磁極部との間に磁気的な空隙を設けたことを特徴とする永久磁石回転電機。

【請求項２】請求項１に記載の永久磁石回転電機において、前記永久磁石挿入孔の底に凹部を設け、該凹部に前記永久磁石を配置したことを特徴とする永久磁石回転電機。

【請求項３】請求項１または請求項２に記載の永久磁石回転電機において、前記空隙に非磁性材料を配置したことを特徴とする永久磁石回転電機。

【請求項４】請求項１ないし請求項３のいずれかに記載の永久磁石回転電機において、前記空隙の固定子側の面の周方向幅を該空隙の反固定子側の面の周方向幅よりも大きくしたことを特徴とする永久磁石回転電機。

【請求項５】請求項４に記載の永久磁石回転電機において、前記空隙の周方向断面は三角形状であることを特徴とする永久磁石回転電機。

【請求項６】請求項１ないし請求項５のいずれかに記載の永久磁石回転電機において、前記磁極片部はブリッジ部を介して前記補助磁極に接続され、前記ブリッジ部の固定子側表面と空隙側表面は略平行であることを特徴とする永久磁石回転電機。

【請求項７】請求項６に記載の永久磁石回転電機において、前記ブリッジ部は、前記空隙の傾斜面に垂直に伸びるよう形成したことを特徴とする永久磁石回転電機。

【請求項８】固定子鉄心に巻線を施した固定子と、間に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に回転空隙をもって配置した永久磁石回転電機において、前記磁極片部と前記補助磁極部との間に磁気的な空隙を設けたことを特徴とする永久磁石回転電機。

【請求項９】請求項８に記載の永久磁石回転電機において、前記空隙は前記永久磁石の固定子側の面の周方向端部に接することを特徴とする永久磁石回転電機。

【請求項１０】請求項９に記載の永久磁石回転電機において、前記空隙は前記永久磁石の内側に伸びていることを特徴とする永久磁石回転電機。

【請求項１１】請求項９に記載の永久磁石回転電機において、前記空隙は前記永久磁石の内側に矩形状に伸びていることを特徴とする永久磁石回転電機。

【請求項１２】固定子鉄心に巻線を施した固定子と、間

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に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に回転空隙をもって配置した永久磁石回転電機において、前記磁極片部と前記補助磁極部との間に磁気的な空隙を設け、非磁性の磁極片支持部材により前記磁極片部を前記補助磁極部に固定せしめたことを特徴とする永久磁石回転電機。

【請求項１３】請求項１２に記載の永久磁石回転電機において、前記磁極片支持部材はコの字形状かつ前記回転子鉄心の両軸から挿入されていることを特徴とする永久磁石回転電機。

【請求項１４】固定子鉄心に巻線を施した固定子と、間に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に回転空隙をもって配置した永久磁石回転電機において、前記磁極片部と前記補助磁極部との間に磁気的な空隙を設け、前記磁極片部と前記永久磁石の間に磁性材料と非磁性材料を組み合わせた永久磁石支持部材を配置し、かつ前記永久磁石支持部材の前記磁性材料を前記磁極片部と前記永久磁石間に配置し、前記非磁性材料を前記補助磁極部に係合させたことを特徴とする永久磁石回転電機。

【請求項１５】請求項８ないし請求項１４のいずれかに記載の永久磁石回転電機において、前記空隙に非磁性材料を配置したことを特徴とする永久磁石回転電機。

【請求項１６】請求項１ないし請求項１５のいずれかに記載の永久磁石回転電機において、前記永久磁石の周方向幅は前記補助磁極部の周方向幅よりも小さいことを特徴とする永久磁石回転電機。

【請求項１７】請求項１ないし請求項１６のいずれかに記載の永久磁石回転電機により駆動される電動車両。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は回転電機および回転電機を用いた電動車両に係り、特に磁束発生手段として永久磁石を用いた永久磁石回転電機、およひ永久磁石回転電機を用いた電動車両に関する。

【０００２】

【従来の技術】従来より回転電機の一種として、回転子の磁界発生手段に永久磁石を用いた永久磁石回転電機が使用されている。

【０００３】従来の永久磁石回転電機としては、表面磁石構造、すなわち隣接する永久磁石か周方向に逆極性となるように、回転子の表面に複数の永久磁石を並置，固定したものがある。

【０００４】しかし、表面磁石構造のものは、遠心力により高速回転時に永久磁石が剥離する可能性が高いことから，回転子内の軸方向へ伸びる孔に永久磁石を挿入，

固定した永久磁石埋め込み構造の永久磁石回転子が特開平5－76146号公報に開示されている。

【０００５】また永久磁石埋め込み構造の回転子にスキューを施す場合の構成を簡素にすることを目的として、回転子内部に設置した各永久磁石の端面から回転子の外周へ空隙を形成したものが特開平5－236687号公報に開示されている。

【０００６】

【発明が解決しようとする課題】しかし、上記の従来技術では、補助磁極によるリラクタンストルクを得ることと、コギングトルクまたはトルク脈動（以下、両者を併せて「トルク脈動」と言う）の減少を両立できないという問題がある。

【０００７】永久磁石埋め込み構造の回転子では、隣接した永久磁石間の回転子部材を補助磁極として利用し、固定子の電機子起磁力の合成ベクトルをこの補助磁極の中心位置より回転方向側に向くように制御することにより、リラクタンストルクを得ることができる。このリラクタンストルクは、永久磁石による主トルクに加算され、回転電機の総トルクを増加し、効率を高めるものである。

【０００８】一方、永久磁石回転電機においては、通電の有無にかかわらず常に磁束を発生している永久磁石を用いるため、回転子は常に永久磁石と固定子突極部との位置関係に応じた力を受け、回転時にはその力が脈動的に変化する。それがトルク脈動となって現れる。これは回転子のスムーズな回転を妨げ、回転電機として安定した動作を得ることができないという問題を生じる。

【０００９】特開平5－76146号公報に記載されている永久磁石回転子は、補助磁極を有していることから、リラクタンストルクを得ることは可能であるが、永久磁石と補助磁極との距離が周方向に微小であることから、そこに磁束密度分布の急激な変化が現れ、トルク脈動が生じる。

【００１０】特開平5－236687号公報に開示されている永久磁石回転電機は、永久磁石間に空隙が設けられていること、または空隙に非磁性体からなる接着性の充填材が充填されていることによって、隣り合った永久磁石間の磁束密度分布変化が緩やかとなり、コギングトルクまたはトルク脈動は発生しにくいが、この空隙または充填材は補助磁極の役目を果たさないので、リラクタンストルクを得ることができない。

【００１１】本発明は上記事情に鑑みて、補助磁極によるリラクタンストルクを得ながら、トルク脈動を抑えることのできる永久磁石回転電機、およびそれを用いた電動車両を提供することを目的とする。

【００１２】

【課題を解決するための手段】請求項１に記載の発明は、固定子鉄心に巻線を施した固定子と、間に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に回転空隙をもって配置した永久磁石回転電機において、前記永久磁石と、前記永久磁石に周方向に隣り合った前記補助磁極部との間に磁気的な空隙を設けたことを特徴とする。

【００１３】この磁気的な空隙は、回転子の周方向における永久磁石と補助磁極間の磁束密度分布変化を緩やかにし、トルク脈動を減少させるものである。よってこの空隙は、単なる空間であってもよいし、非磁性材料を配置または充填したものであってもよい。

【００１４】またこの空隙は、永久磁石の両端にあってもよく、また回転電機の回転方向やその用途によっては、永久磁石の周方向どちらか一端のみにあってもよい。

【００１５】しかし上記空隙を永久磁石の周方向端部に設けることにより、高速回転時などに磁石の位置決めが不安定になる可能性がある。そこで請求項２に記載のように、前記永久磁石挿入孔の底に凹部を設け、該凹部に前記永久磁石を配置する、または請求項３に記載のように、前記空隙に非磁性材料を配置させることで、永久磁石を位置決めすることが可能である。

【００１６】また前記空隙は、固定子に対する磁束密度分布変化を緩やかにするものであれば足りることから、その形状を変化させることにより、補助磁極の作用を補助することも可能である。すなわち請求項４に記載のように、前記空隙の固定子側の面の周方向幅を該空隙の反固定子側の面の周方向幅よりも大きくする、または請求項５に記載のように、前記空隙の周方向断面を三角形状になるよう構成することにより、補助磁極の磁束が永久磁石を周回し易いように構成することも可能であり、より多くのリラクタンストルクを得ることができる。

【００１７】さらには、請求項６に記載のように、前記磁極片部はブリッジ部を介して前記補助磁極に接続され、前記ブリッジ部の固定子側表面と空隙側表面を略平行に形成する、または請求項７に記載のように、前記ブリッジ部は前記空隙の傾斜面に垂直に伸びるよう形成することにより、永久磁石から空隙の固定子側の部材から補助磁極へ漏洩する磁束を抑えることが可能である。

【００１８】特に請求項７に記載の発明によれば、永久磁石にかかる遠心力をブリッジ部の引っ張り力によって支えることができ、より高速回転が可能な永久磁石回転電機を提供できる。

【００１９】請求項８に記載の発明は、固定子鉄心に巻線を施した固定子と、間に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に回転空隙をもって配置した永久磁石回転電機において、前記磁極片部と前記補助磁極部との間に磁気的な空

隙を設けたことを特徴とする。

【００２０】この磁気的な空隙も、請求項１に記載の発明と同様に、回転子の周方向における永久磁石と補助磁極間の磁束密度分布変化を緩やかにし、トルク脈動を減少させる。

【００２１】また、請求項９に記載のように前記空隙を前記永久磁石の固定子側の面の周方向端部に接するよう、または請求項１０に記載のように前記空隙を前記永久磁石の内側に伸びるよう、若しくは請求項１１に記載のように前記空隙を前記永久磁石の内側に矩形状に伸びるよう形成することによって、永久磁石の固定子側の面から補助磁極部に漏洩する磁束を抑えることが可能である。

【００２２】しかし、インナロータ型の回転電機において、永久磁石の固定子側にある磁極片部に空隙を設けることは、高速回転時に、永久磁石への遠心力に対する支持力を損なわせる可能性がある。

【００２３】そこで請求項１２に記載のように、固定子鉄心に巻線を施した固定子と、間に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に回転空隙をもって配置した永久磁石回転電機において、前記磁極片部と前記補助磁極部との間に磁気的な空隙を設け、非磁性の磁極片支持部材により前記磁極片部を前記補助磁極部に固定せしめること、または請求項１３に記載のように、前記磁極片支持部材はコの字形状かつ前記回転子鉄心の両軸から挿入されていることにより、磁極片部にかかる永久磁石の遠心力を補助磁極部で支えることができる。

【００２４】また、請求項１４に記載のように、固定子鉄心に巻線を施した固定子と、間に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に回転空隙をもって配置した永久磁石回転電機において、前記磁極片部と前記補助磁極部との間に磁気的な空隙を設け、前記磁極片部と前記永久磁石の間に磁性材料と非磁性材料を組み合わせた永久磁石支持部材を配置し、かつ前記永久磁石支持部材の前記磁性材料を前記磁極片部と前記永久磁石間に配置し、前記非磁性材料を前記補助磁極部に係合させることによっても、同様に永久磁石の受ける遠心力に対する支持力を増加させることができる。

【００２５】さらには、請求項１５に記載のように、前記空隙に非磁性材料を配置することによっても、永久磁石の受ける遠心力に対する支持力を増加させることができる。

【００２６】また請求項１６に記載のように、前記永久磁石の周方向幅を前記補助磁極部の周方向幅よりも小さくすることによっても、永久磁石にかかる遠心力を有効に軽減することができる。

【００２７】請求項１７に記載の発明は、請求項１ないし請求項１６に記載の永久磁石回転電機により駆動される電動車両であり、コギングトルクの少ない、安定した駆動装置を持つ電動車両を提供することができる。

【００２８】なお、上記回転電機は、発電機及び電動機、インナロータ及びアウタロータ，回転型及びリニア型，集中巻及び分布巻き固定子構造のいずれのものであっても、本発明を適用可能である。

【００２９】また上記全ての発明は、永久磁石の形状に依存せず、直方体，アーク形，台形等，どのようなものでも適用可能であり、同様の効果を奏する。

【００３０】

【発明の実施の形態】以下、本発明の実施形態を図を用いて詳細に説明する。

【００３１】図１は本発明の一実施形態であるインナロータ型集中巻固定子構造の永久磁石回転電機の周方向断面図を示す。

【００３２】回転電機は固定子１と回転子２から構成され、これらは図のように互いに回転空隙をもって配置される。

【００３３】固定子１は、固定子鉄心３と固定子巻線４からなり、固定子鉄心３は更にコア部５と固定子突極部６とから構成される。コア部５には固定子突極部６に磁束を通すための磁気回路が形成され、固定子突極部６には固定子巻線４が集中的に巻回される。

【００３４】回転子２はシャフト７，回転子鉄心８、および永久磁石９からなる。回転子鉄心８には、永久磁石９を挿入する永久磁石挿入孔１０およびシャフト７を通す孔が軸方向に打ち抜かれ、それぞれ永久磁石９およびシャフト７が挿入，固定される。

【００３５】このように本実施形態はいわゆる永久磁石埋め込み構造のものであり、永久磁石９を回転子２に環状に配置することによって、互いに隣接する永久磁石挿入孔１０の間の部材を補助磁極部１６として機能させることができる。

【００３６】すなわち、図示しない制御装置によって、固定子巻線４による電機子起磁力の合成ベクトルを補助磁極の中心位置より回転方向側に向くように制御すれば、固定子巻線４から発生した磁束が補助磁極部１６を介して永久磁石９を周回し、リラクタンストルクが発生する。これは特に低速運転状態において有効であり、上記リラクタンストルクが永久磁石９による通常のトルクに加わることで、電動機として高いトルクを得ることができる。

【００３７】図３は本実施形態に係る永久磁石回転電機の軸方向の断面構造を示す。

【００３８】固定子１はハウジング１１の内周面に図のように固定され、また回転子２に挿入，固定されたシャ

フト７は、回転子２が固定子１に回転空隙をもって回転自在に接するよう、ベアリング１３およびエンドブラケット１２によって固定子１に保持される。

【００３９】本実施形態では、回転子鉄心８の材料として永久磁石９よりも高い透磁率を有するもの、例えば珪素鋼板のような高透磁率磁性材料を用いる。これにより、磁石内部に発生する渦電流損を減少させることができ、また前述の補助磁極部１６をより有効に機能させることができる。

【００４０】なお本発明は、発電機及び電動機、インナーロータ及びアウターロータ、回転型及びリニア型、集中巻き及び分布巻き固定子構造のいずれにおいても適用可能であり、同様の効果が得られる。

【００４１】本実施形態は、永久磁石９と、該永久磁石９に周方向に隣り合った補助磁極部１６との間に磁気的な空隙１４を設けるものである。

【００４２】図２に図１における任意の永久磁石９の周辺を拡大した図を示す。図のように、永久磁石９の周方向端部に空隙１４を設けるように永久磁石挿入孔１０を形成し、そこに永久磁石９を挿入，固定する。この空隙は軸方向に伸び、永久磁石９と補助磁極部１６に接している。

【００４３】この空隙１４の作用を図４および図５を用いて説明する。

【００４４】図４および図５は、永久磁石９周辺の周方向断面図と、永久磁石９によって回転子２の周表面から発生される磁束密度分布の関係を表した図である。図４は前述の実施形態を用いた回転子を、図５は従来の回転子を示す。

【００４５】双方とも、回転子鉄心８の磁極片部１５は、永久磁石９が発生した磁束を固定子１へ伝達する部材として機能する。また隣り合った永久磁石挿入孔１０の間の部材、すなわち図中の補助磁極部１６はリラクタンストルクを発生する補助磁極として機能する。

【００４６】図４および図５の上部にあるグラフは、永久磁石９によって回転子２の固定子側表面から発生される磁束密度分布を表している。両図ともに、磁極片部１５では、永久磁石９の発生する磁束ははぼ一定の磁束密度分布を示す。一方、補助磁極部１６では、永久磁石９による磁束が伝達されにくく、回転子２の固定子側表面から発生される磁束はほぼ零となる。

【００４７】しかし、従来の回転子においては、図５のように回転子鉄心８に設けられた永久磁石挿入孔１０全体を埋めるように永久磁石９が配置されていることから、磁極片部１５と補助磁極部１６の境界付近において図のような急激な磁束密度分布の変化が現れる。

【００４８】永久磁石回転電機においては、回転電機への通電の有無にかかわらず、永久磁石が常に磁束を発生しているため、回転子は、常に固定子突極部６と磁極片部１５との位置関係に応じた力を受ける。回転子が回転

すれば、互いの位置が変化することにより回転子の受ける力が脈動的に変化し、これがコギングトルクやトルク脈動となって現れる。回転子周方向における磁束密度分布の変化が急激なほど、トルク脈動は顕著である。

【００４９】そこで本実施形態のように空隙１４を設け、磁束密度分布の変化を緩やかなものにする。空隙１４によって、回転子表面の補助磁極部１６と磁極片部１５の間にブリッジ部１７が形成され、磁極片部１５と補助磁極１６の間に距離が設けられる。従って、図４のグラフのように従来に比べて緩やかな磁束密度分布の変化が現れ、コギングトルクやトルク脈動を抑制することができる。

【００５０】また、回転方向が一方向のみに定まっている回転電機では、永久磁石９の周方向一端にのみ磁気的な空隙１４を設けても良い。

【００５１】なお本実施形態においては図のような直方体の永久磁石９を用いているが、他の形状のもの、例えばアーク形や台形のものに同様の空隙１４を形成しても同様の効果が得られる。

【００５２】図６ないし図８には、本発明の他の実施形態を示す。

【００５３】図６および図７の実施形態は図２における実施形態の空隙１４の形状を変化させたものである。

【００５４】図６の実施形態は、永久磁石挿入孔１０の底に凹部を設け、該凹部に永久磁石９を配置したものである。その結果、空隙１４の回転子半径方向の厚さは永久磁石９の回転子半径方向の厚さよりも小さく形成され、図のように空隙１４の反固定子側の面が永久磁石９の反固定子側の面よりも固定子寄りに形成される。

【００５５】これらにより永久磁石９を永久磁石挿入孔１０の所定の位置に位置決めすることができる。

【００５６】また永久磁石９の位置決めのためには、空隙１４に非磁性材料を配置または充填しても同様の効果を得ることができる。例えば空隙１４に非磁性材料から成る固体を配置し、一体にワニス及び接着剤で固着させることによって、永久磁石９をより安定して配置することができる。

【００５７】また図７の実施形態は、空隙１４の固定子側の面の周方向幅を反固定子側の面の周方向幅よりも大きくしたものである。図７では特に空隙１４の周方向断面が略三角形状となるように形成する。このことによって、補助磁極部１６を通る磁束がスムーズに永久磁石９を周回することができ、リラクタンストルクをより多く得ることができる。

【００５８】さらに図６および図７の実施形態においては、回転子２の固定子側表面に略平行となるように空隙１４の固定子側の面を形成する。

【００５９】これによって、ブリッジ部１７の磁気的な飽和はきつくなり、永久磁石９から発生する磁束が磁極片部１５，ブリッジ部１７を介して補助磁極部１６に漏

洩する磁束を抑制することができる。

【００６０】図８の実施形態は、同様の構成を得るため、逆に回転子２の形状を変更したものである。すなわちブリッジ部１７が空隙１４の傾斜面１４ａに略垂直に伸びるよう構成される。このことにより、回転子２の半径方向に対するブリッジ部１７の傾きが大きくなり、磁極片部１５及び永久磁石９にかかる遠心力をブリッジ部１７の引っ張り力により支えることができる。一般的に材料の耐久性は、剪断力に対するよりも引っ張り力に対する方が高く、ブリッジ部１７が回転子２の半径方向に対してほぼ直角をなす前述の実施形態よりも遠心力に対する耐久性が高い。従ってブリッジ部１７をより薄く形成し、永久磁石９から発生する有効磁束量を高めることも可能であり、またより高速に回転子を回転することができる。

【００６１】図９ないし図１１に本発明の他の実施形態を示す。

【００６２】これらは、磁極片部１５と補助磁極部１６の間に磁気的な空隙１４を設けるものであり、図のように磁極片部１５の両端に空隙１４が形成される。この空隙１４は、永久磁石９の固定子側周方向縁部に沿って軸方向に伸びている。この空隙１４により、図のようなブリッジ部１７が形成され、その部分における磁束密度分布が緩やかに変化し、コギングトルクを抑制することが可能となる。

【００６３】さらに図９ないし図１１では、空隙１４が永久磁石９の固定子側の面の周方向端部に接し、かつ永久磁石９の周方向端面より内へ入り込むように形成する。また図１０では空隙１４が永久磁石９の内側に向かって伸びるように形成し、図１１では空隙１４が永久磁石９の内側に矩形状に伸びるように形成する。

【００６４】このことにより、補助磁極部１６に漏洩する磁束が減少し、磁極片部１５における磁束密度が高まることにより、回転電機として効率を高めることができる。図１２ないし図１４に、本発明の他の実施形態を示す。

【００６５】永久磁石埋め込み構造の回転子を高速に回転させたとき、永久磁石の受ける遠心力が増加し、永久磁石を支持する部材、すなわち磁極片部１５やブリッジ部１７の負担が増加する。その負担に対応し、該部材を厚く設けた場合、回転子表面と永久磁石との距離が大きくなること、および磁束が補助磁極部１６に漏洩することにより、永久磁石から固定子に対して伝達される磁束が減少し、トルクが減少するという問題が生じる。

【００６６】そこで、永久磁石９の固定子側の面の周方向両端に図１２のような断面で軸方向に伸びる磁気的な空隙１４を形成し、空隙１４を挟むように磁極片部１５と補助磁極部１６に磁極片支持部材１８を軸方向に差し込み固定する。図１３は磁極片支持部材１８の例であり、ここではコの字形をした非磁性の樹脂とする。図１４に磁極片支持部材１８が回転子鉄心８の両側から差し込まれた回転子２を持つ永久磁石回転電機の軸方向断面図を示す。

【００６７】ここで空隙１４は、磁極片部１５から補助磁極部１６へ漏洩する磁束を抑制する。また磁極片支持部材１８は、磁極片部１５にかかる永久磁石９および磁極片部１５自身の遠心力を、補助磁極部１６をもって支えるための媒体として働く。このことにより、遠心力に対する永久磁石の支持力を高めることができる。

【００６８】さらには、図１２におけるブリッジ部１７を回転子２の組立後に切削することにより、磁極片支持部材１８により磁極片部１５の支持力を維持しながら、ブリッジ部１７による漏洩磁束も減少させることができる。

【００６９】図１５に本発明の他の実施形態を示す。

【００７０】ここでは、図のように磁極片部１５と補助磁極部１６の間に磁気的な空隙１４を形成し、永久磁石９と磁極片部１５の間に磁性材料と非磁性材料を組み合わせた永久磁石支持部材１９を設ける。

【００７１】永久磁石支持部材１９は、図のように磁性材料１９ａと非磁性材料１９ｂの組み合せであり、両者は例えば溶接などによって接合する。磁性材料１９ａは永久磁石９の発生磁束を磁極片部１５に伝達するために磁性体の材料で構成し、非磁性材料１９ｂは永久磁石９から補助磁極部１６への漏洩磁束を抑制するために非磁性体の材料で構成する。

【００７２】以上の構成によって、永久磁石９にかかる遠心力を永久磁石支持部材１９を介し補助磁極部１６で支持することができ、ブリッジ部１７には磁極片部１５の遠心力がかかるのみとなる。よって、ブリッジ部１７の半径方向の長さを短くでき、従って永久磁石９からの磁束漏洩を少なくすることができる。

【００７３】あるいは、図９ないし図１１の実施形態において、空隙１４に非磁性材料を配置または充填することも有効である。

【００７４】磁極片部１５の厚さを十分な磁束を得るために必要な厚さに設定し、空隙１４を永久磁石９の固定子側に図９ないし図１１のような形状で打ち抜き、そこに非磁性の材料、例えば接着剤、ワニスを充填する構成とする。このことによって、磁極片部１５を半径方向に厚くすることなく、永久磁石９や磁極片部１５が受ける遠心力を空隙１４によって支えることができる。

【００７５】また、永久磁石９の材料として、樹脂磁石を用いることも可能である。この場合、空隙１４に充填する非磁性の材料の代わりに、樹脂磁石を永久磁石挿入孔１０と空隙１４を合わせた形状で嵌め込むことができる。すなわちプラスチックマグネット自身に空隙１４の上記のような役割を兼ねさせることが可能となる。さらには、図１６のように永久磁石９の周方向幅よりも補助磁極部１６の周方向幅を大きく設けることも有効であ

る。

【００７６】このことにより、ブリッジ部１７にかかる遠心力を作り出す永久磁石９の重量が軽減され、ブリッジ部１７の厚さをより小さくすることができ、磁極片部１５から補助磁極部１６に漏洩する磁束を減少することができる。

【００７７】なお、永久磁石９の周方向幅が小さくなることによって、永久磁石９から発生する磁束は減少するが、相対的に補助磁極部１６によるリラクタンストルクは増加する。これは永久磁石９として高価なネオジウム磁石を用いた場合などに有効であり、永久磁石９の量を減らすことによるコストダウンの分を、補助磁極部１６のリラクタンストルクで補うことにより、コストパフォーマンスの向上を図ることができるものである。

【００７８】なお、以上に述べた永久磁石回転電機を電動車両、特に電気自動車に適用すれば、コギングトルクが少なく、スムーズに発進できる安定した永久磁石回転電機駆動装置を搭載でき、一充電走行距離の長い電気自動車を提供することができる。

【００７９】

【発明の効果】請求項１に記載の発明によれば、トルク脈動の少ない永久磁石回転電機を構成できる。

【００８０】請求項２および請求項３に記載の発明によれば、請求項１と同様の効果に加えて、永久磁石の位置決めが可能となる。

【００８１】請求項４および請求項５に記載の発明によれば、さらに補助磁極を通る磁束がスムーズに永久磁石を周回するよう構成することが可能である。

【００８２】請求項６および請求項７に記載の発明によれば、さらに永久磁石から空隙の固定子側の部材から補助磁極へ漏洩する磁束を抑えることが可能となる。

【００８３】また請求項８に記載の発明によっても、トルク脈動の少ない永久磁石回転電機を実現できる。

【００８４】請求項９ないし請求項１１に記載の発明によれば、請求項８と同様の効果に加えて、永久磁石の固定子側の面から補助磁極部に漏洩する磁束を抑えることができる。

【００８５】さらに請求項１２ないし請求項１６に記載の発明によれば、トルク脈動の減少という効果に加えて、永久磁石にかかる遠心力に対する支持力を確保することができる。

＊【００８６】請求項１７に記載の発明によれば、コギングトルクの少ない、安定した駆動装置を持つ電動車両を提供することができる。

【図面の簡単な説明】

【図１】本発明の一実施形態をなす永久磁石回転電機の周方向断面図。

【図２】図１の回転子の任意の永久磁石周辺の拡大図。

【図３】図１の実施形態の軸方向断面図。

【図４】図２の回転子部材の機能説明図と磁束密度分布。

【図５】従来の永久磁石回転電機の回転子部材の機能説明図と磁束密度分布。

【図６】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図７】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図８】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図９】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図１０】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図１１】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図１２】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図１３】図１２の磁極片支持部材の斜視図。

【図１４】図１２の永久磁石回転電機の軸方向断面図。

【図１５】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図１６】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【符号の説明】

１…固定子、２…回転子、３…固定子鉄心、４…固定子巻線、５…コア部、６…固定子突極部、７…シャフト、８…回転子鉄心、９…永久磁石、１０…永久磁石挿入孔、１１…ハウジング、１２…エンドブラケット、１３…ベアリング、１４…空隙、１５…磁極片部、１６…補助磁極部、１７…ブリッジ部、１８…磁極片支持部材、１９…永久磁石支持部材。

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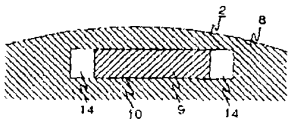
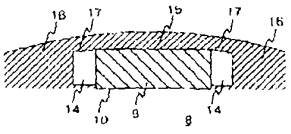
【図２】

図 2



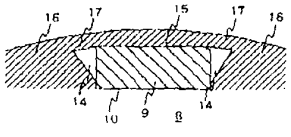
【図６】

図 6



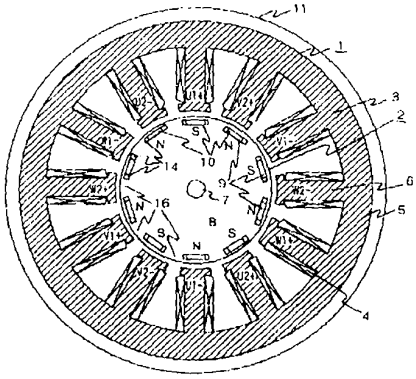
【図７】

図 7



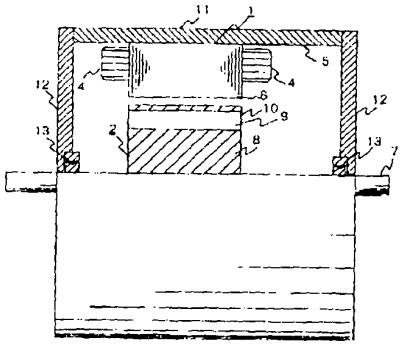
【図１】

図 1



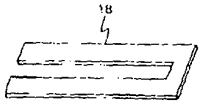
【図３】

図 3



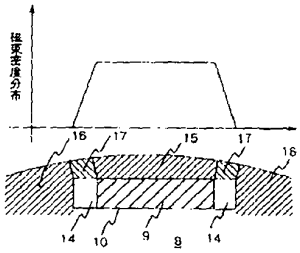
【図１３】

図 13



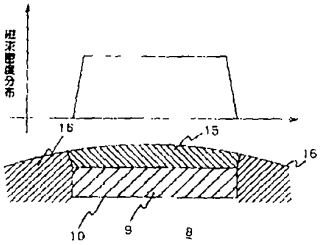
【図４】

図 4



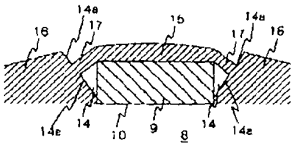
【図５】

図 5



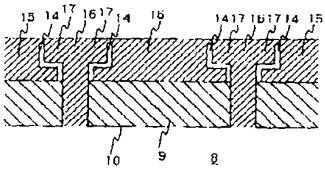
【図８】

図 8



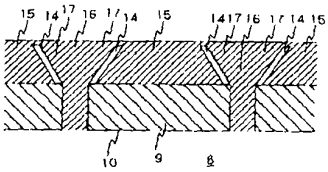
【図９】

図 9



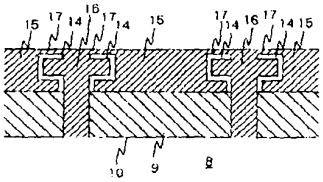
【図１０】

図 10



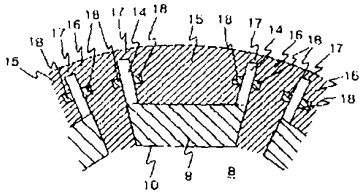
【図１１】

図 11



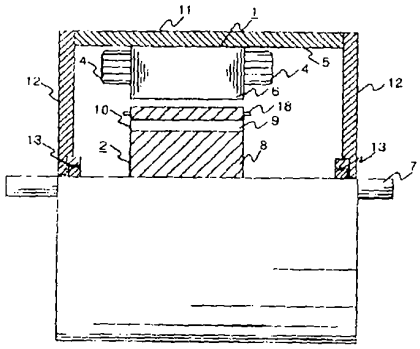
【図12】

図 12



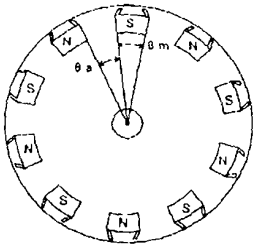
【図14】

図 14



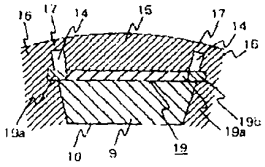
【図16】

図 16



【図15】

図 15



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【補正対象項目名】特許請求の範囲
【補正方法】変更
【補正内容】
【特許請求の範囲】
【請求項１】固定子と、該固定子の内周側に空隙を介して配置された回転子と、該回転子に形成されると共に環状に配置された複数の永久磁石挿入孔と、該複数の永久磁石挿入孔に埋め込まれた永久磁石と、前記回転子に形成されると共に周方向に隣接する前記永久磁石間に設けられた補助磁極部とを有し、前記永久磁石と前記補助磁極部の間には磁気的な空隙が設けられていることを特徴とする永久磁石回転電機。
【請求項２】固定子と、該固定子の内周側に空隙を介して配置された回転子と、該回転子に形成されると共に環状に配置された複数の永久磁石挿入孔と、該複数の永久磁石挿入孔に埋め込まれた永久磁石と、前記回転子に形成されると共に周方向に隣接する前記永久磁石間に設けられた補助磁極部と、前記永久磁石の前記固定子側に配置された磁極片部とを有し、前記補助磁極部と前記磁極片部の間には磁気的な空隙が設けられていることを特徴とする永久磁石回転電機。
【請求項３】請求項１又は２に記載の永久磁石回転電機において、前記空隙には非磁性材が設けられていることを特徴とする永久磁石回転電機。
【請求項４】請求項１又は２に記載の永久磁石回転電機において、前記空隙は、磁束密度分布の変化を緩やかにしてコギングトルクを抑制させるものであることを特徴とする永久磁石回転電機。
【請求項５】駆動装置を備えた電動車両において、前記駆動装置は、請求項１乃至４のいずれかに記載の永久磁石回転電機を有することを特徴とする電動車両。